Appendix D-2
Electric Vehicle Safe Design Checklist

**IMPORTANT USER NOTE: This document was created in 2014 by the DoD Electrical Safety Working Group (ESWG) and is based on Codes and Standards in force in 2014. To use this checklist properly, the user must refer to the code in force at the date of use.*

Purpose: This checklist may be used to evaluate integration of safe design parameters for electrical systems and equipment in electric vehicles. It also includes important standard vehicle safety equipment considerations found lacking in some early models of electric vehicles. This checklist is appropriate for use with plug-in electric vehicles; plug-in hybrids, extended-range electric vehicles, and battery electric vehicles. Battery electric vehicles have no gasoline engine and run exclusively on the energy stored in the on-board batteries.

Requirements: Applicable Codes and Standards related to electrical safety have been developed by the National Fire Protection Association (NFPA), the Institute for Electrical and Electronics Engineering (IEEE), Underwriter's Laboratory (UL), and SAE International.

Applicability: This checklist is a tool to aid in safe design of electrical vehicles as well as in evaluation of commercially available products to assure considerations have been made for safety.

Electric Vehicle Safe Design Checklist

Vehicle Make and Model: _____
Battery Pack Type: _____
Date of Design Review: _____
Reviewer Name: _____
Job Title: _____
Email: _____
Phone #: _____

Number	Item	Y/N/NA	Comments
1	Describe the battery pack location on the vehicle.		
2	Who is responsible for the vehicle maintenance i.e., government, manufacturer or other? Do training and competency requirements include knowledge of electrical systems and safety commensurate with the vehicle's electrical system?		
3	Is the vehicle battery pack mounted in a suitable enclosure (steel or other suitable material) and protected from weather, dirt, impacts and punctures? Describe.		
4	Does the vehicle have signage to be easily identified as an "electric" vehicle? Describe.		
5	Does the vehicle have an emergency battery "Kill Switch" other than turning the vehicle off at the ignition? If so, where is it or are they located? There could be (2+) locations.		

Electric Vehicle Safe Design Checklist

Number	Item	Y/N/NA	Comments
6	Does the vehicle have a high voltage crash sensor for automatic high voltage disconnect?		
7	Does the vehicle have a rollover sensor for high voltage disconnect?		
8	Are all voltage cables in protected casings and color coded (specifically high voltage cables identified in orange) to prevent high voltage electrical shock? If not, describe.		
9	Are electrical circuits fuse protected from high voltage? Especially safety critical systems such as braking and steering.		
10	Is the vehicle equipped with a battery management system to monitor battery modules (integrity) while charging and discharging to protect the batteries from damage, prolong life and maintain the battery state and functionality requirements?		
11	Does the battery pack require equalization? If so, who will do that other than the driver?		
12	If a battery pack needs replacement/removal from the vehicle, what is the weight of the battery pack and how will it be lifted from the vehicle? Describe.		
13	Is the vehicle equipped with an onboard system that monitors and transmits the vehicle's vital statistics by general packet radio service (GPRS) to a central server, allowing remote vehicle monitoring, diagnostics and reporting?		

Electric Vehicle Safe Design Checklist

Number	Item	Y/N/NA	Comments
14	Is there a charging breaker on the vehicle to prevent overcurrent from the charging station?		
15	Does the vehicle have driver emergency audible or visible "alerts"? If so, list all of them.		
16	Does the battery pack have containment compartments in case of leaks? If so, describe?		
17	Have any Government modifications been made to the vehicle's engine, truck bed, wheels, axles, transmission or other? If so, please describe. If so, was the modification approved by the manufacturer?		
18	Have any new gauges been added to the vehicle by the government, such as heater, fan, reporting or tracking instruments or other? If so, please describe.		
19	If so, were both the new gauge and its install placement approved by the manufacturer?		
20	Does the vehicle make "noise" so pedestrians can "hear" the vehicle when in drive? If yes, describe.		
21	Is the vehicle equipped with airbags? List the locations. i.e. Front, side or other		
22	In the event of an accident, are the vehicle bumpers crash-worthy? If not, describe.		
23	Are the ignition switches solidly built?		

Electric Vehicle Safe Design Checklist

Number	Item	Y/N/NA	Comments
24	Are there unusual starting or stopping procedures? i.e. several switches needed before start		
25	Does the steering track back to center?		
26	Is vehicle equipped with speed controller via speed limiter or governor?		
27	Is vehicle equipped with adequate mirrors? i.e. blind spots side, front lower and back		
28	Is vehicle equipped with seat and lap belts?		
29	Are operational controls reachable by driver? i.e. no controls on passenger side		
30	Is the seat adjustable? i.e. up and down, front and back		
31	Is the steering wheel adjustable for shorter people and larger people?		
32	Are pedals standard and easy to reach?		
33	Can the vehicle be towed in case of inoperable vehicle? Describe type: (flat tow automatic or manual is typically required to not damage the battery pack and tow dollies are typically never allowed)		
34	Is the trunk and hood equipped with safety mechanism to hold the hood and trunk up in a safe manner, to allow maintenance, usage or other? i.e. rod and hook, latch or other Describe.		

Electric Vehicle Safe Design Checklist

Number	Item	Y/N/NA	Comments
35	Are there any special procedures when a tire rotation or change is required on the vehicle? If so, describe.		
36	If cargo truck, are restraints provided/installed to restrain the transported items safely? Describe.		
37	Do the Operator and Maintenance Manuals have the warnings and cautions adequately marked?		
38	Is an emergency road side kit provided and located in the vehicle? If so, where is it located?		
39	Have critical functional failure modes been identified and detection methods incorporated?		
40	In the event of a battery pack or electrical fire, what procedures are in place to extinguish the fire?		
41	**NHTSA-FMVSS-SAE-UL Standards and Exemptions:** Are there any active exemptions on the vehicle of interest? If so, please list exemption # and title, date of petition/granted and a brief description of status of exemptions. Also, SAE has listed "Recommended" standards such as J1766 and J1797. Please advise if the vehicle of interest meet or work is in progress to meet any "recommended" standards of this nature		

Additional Codes and Standards Related to Electrical Safe Design of Hybrid Electric Vehicles (EVs and HEVs) Promulgated Through 2015

Note: the EV Checklist was developed in 2013. These additional requirements should be incorporated into EV s developed or manufactured after date of promulgation.

Code/Standard Number and Edition Year	Code/Standard Title and Summary
NFPA 70, 2014	*National Electrical Code (NEC)®* Article 625, Electric Vehicle Charging System
UL 2594, 2013	*Standard for Electric Vehicle Supply Equipment* Covers conductive EV supply equipment with a primary source voltage of 600 V AC or less, with a frequency of 60 Hz, and intended to provide AC power to an electric vehicle with an on-board charging unit. This Standard covers electric vehicle supply equipment intended for use where ventilation is not required.
SAE J1495, 2013	*Test Procedure for Battery Flame Retardant Venting Systems* Details procedures for testing lead-acid EV batteries to determine the effectiveness of the battery venting system to retard the propagation of an externally ignited flame of hydrogen battery gas into the interior of the battery where an explosive mixture is usually present.
SAE J-1715, 2014	*Hybrid Electric Vehicle (HEV)and Electric Vehicle Terminology* Contains definitions for HEV and EV terminology. It is intended that this document be a resource for those writing other HEV and EV documents, specifications, standards, or recommended practices.

Code/Standard Number and Edition Year	Code/Standard Title and Summary
SAE J-1766, 2014	*Recommended Practice for Electric Fuel Cell and Hybrid Electric Vehicle Crash Integrity Testing* This SAE Recommended Practice is applicable to Electric, Fuel Cell and Hybrid vehicle designs that are comprised of at least one vehicle propulsion voltage bus with a nominal operating voltage greater than 60 and less than 1,500 VDC, or greater than 30 and less than 1,000 VAC. Adequate barriers between occupants and the high voltage systems are necessary to provide protection from potentially harmful electric current and materials within the high voltage system that can cause injury to occupants of the vehicle during and after a crash. This Recommended Practice addresses post-crash electrical safety, retention of electrical propulsion components and electrolyte spillage.
SAE J-2289, 2008	*Electric-Drive Battery Pack System: Functional Guidelines* This SAE Information Report describes common practices for design of battery systems for vehicles that utilize a rechargeable battery to provide or recover all or some traction energy for an electric drive system. It includes product description, physical requirements, electrical requirements, environmental requirements, safety requirements, storage and shipment characteristics, and labeling requirements.
SAE J-2344, 2010	*Guidelines for Electric Vehicle Safety* Identifies and defines the preferred technical guidelines relating to safety for vehicles that contain High Voltage (HV), such as Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Plug-In Hybrid Electric Vehicle (PHEV), fuel Cell Vehicles (FCV) and Plug-In fuel Cell Vehicles (PFCV) during normal operation and charging,

Code/Standard Number and Edition Year	Code/Standard Title and Summary
SAE J-2380, 2013	*Vibration Testing of Electric Vehicle Batteries* Describes the vibration durability testing of a single battery consisting of either an electric vehicle battery module or an electric vehicle battery pack.
SAE J-2464, 2009	*Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing* Intended as a guide toward standard practice and is subject to change to keep pace with experience and technical advances. It describes a body of tests which may be used as needed for abuse testing of electric or hybrid electric vehicle Rechargeable Energy Storage Systems (RESS) to determine the response of such electrical energy storage and control systems to conditions or events which are beyond their normal operating range.
SAE J-2836-1, 2010	*Use Cases for Communication Between Plug-in Vehicles and the Utility Grid* Establishes use cases for communication between plug-in electric vehicles and the electric power grid, for energy transfer and other applications.
SAE J-2894-2, 2015	*Power Quality Test Procedures for Plug-In Electric Vehicle Chargers* Addresses automatic charger restarts after a sustained power outage, as well as the ability to ride through momentary outage.

Code/Standard Number and Edition Year	Code/Standard Title and Summary
SAE J-2929, 2013	*Electric and Hybrid Vehicle Propulsion Battery System Safety Standard – Lithium-based Rechargeable Cells* Defines a minimum set of acceptable safety criteria for a lithium-based rechargeable battery system to be considered for use in a vehicle propulsion application as an energy storage system connected to a high voltage power train. While the objective is a safe battery system when installed into a vehicle application, this Standard is primarily focused, wherever possible, on conditions which can be evaluated utilizing the battery system alone.
SAE J-2931-1, 2014	*Digital Communications for Plug-in Electric Vehicles* Establishes the requirements for digital communication between Plug-In Electric Vehicles (PEV), the Electric Vehicle Supply Equipment (EVSE) and the utility or service provider, Energy Services Interface (ESI), Advanced Metering Infrastructure (AMI) and Home Area Network (HAN).
SAE J-2953-1, 2013	*Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)* Establishes requirements and specification by which a specific Plug-In Electric Vehicle (PEV) and Electric Vehicle Supply Equipment (EVSE) pair can be considered interoperable.